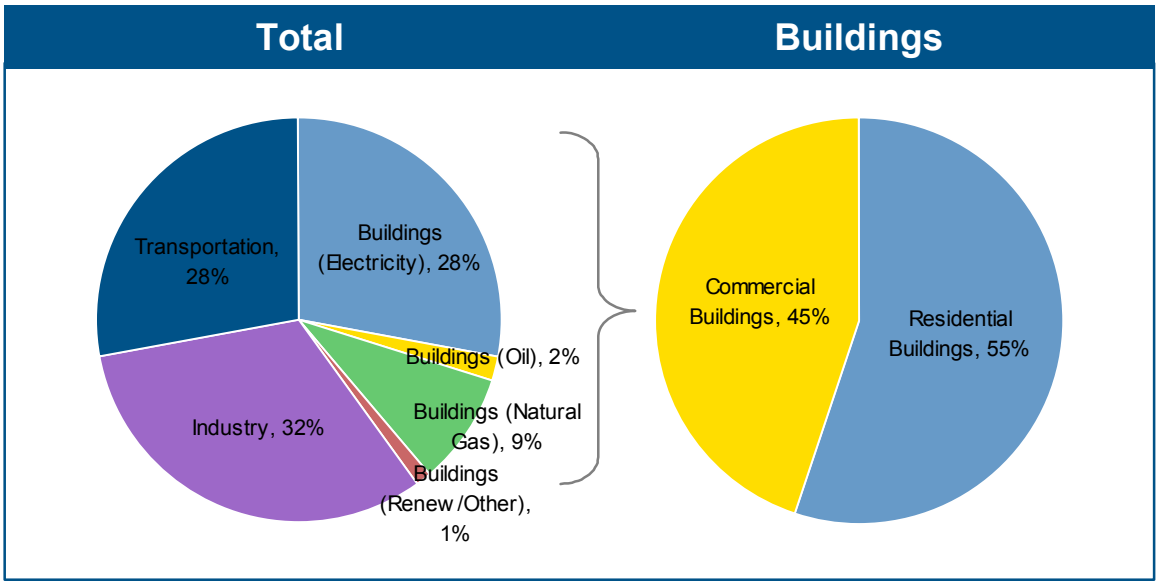
1 Program Overview

1.1 External Assessment and Market Overview

The Nation's 112 million households and over 4.7 million commercial buildings consume approximately 38.8 quadrillion Btu (quads) of energy annually, about 40 percent of the U.S. total, making the building sector the largest sectoral energy consumer[1] (See Figure 1-1). Buildings are also the dominant consumer of electricity – homes and buildings use 71 percent of all electricity generated nationally, with the balance consumed by industry.

Figure 1-1 U.S. Primary Energy Consumption, 2003[2]

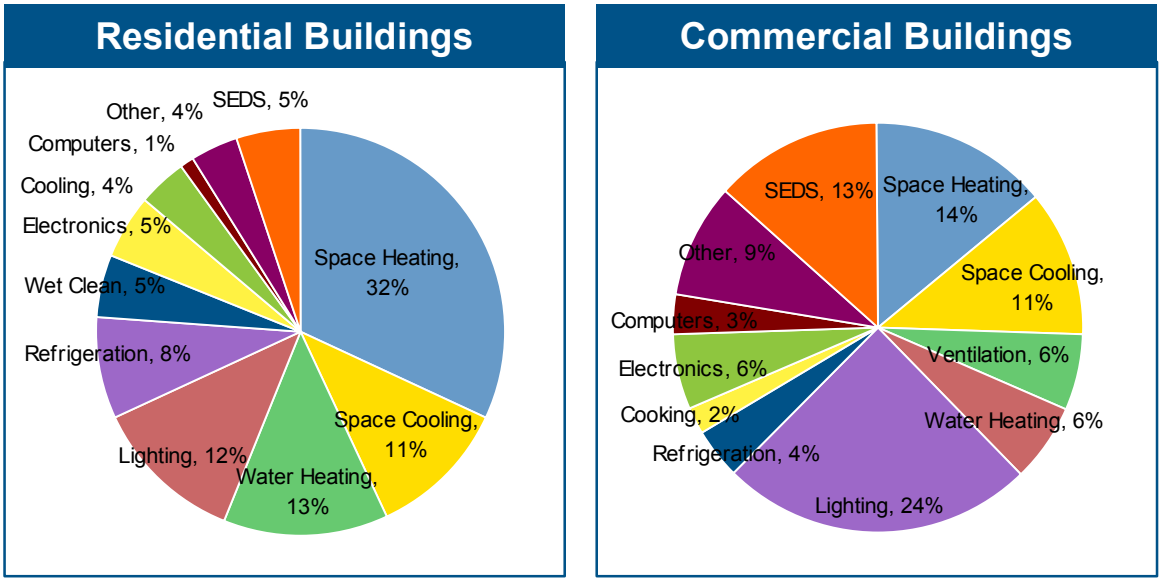


Patterns of energy use in "average" homes and commercial buildings differ significantly, as Figure 1-2 below indicates. In the residential sector, space heating, water heating, lighting, space cooling, and refrigeration are the largest end uses. There is significant variation in end-use demand in real households, due to variation across climate zones (from Fairbanks to Key West), type of building (single family detached versus 20 story apartment building), and demographics of the household (number of occupants, patterns of occupancy, demand for services, and income level).

[1] *2005 Building Energy Data Book*, U.S. Department of Energy, Office of Planning, Budget Formulation and Analysis, Energy Efficiency and Renewable Energy. Prepared by D&R International, Ltd., August 2005. Hereafter, BED.
[2] BED

For example, energy required to provide water heating services to a senior citizen living in North Carolina will be very different than that of a family of five in North Dakota – and that difference will go a long way to defining the markets for advanced and innovative approaches to water heating.

Figure 1-2 Energy Use in Residential and Commercial Buildings, 2003[3]



In commercial buildings, lighting is the most significant energy user nationally, at 4.3 quadrillion Btu per year. Moreover, lighting's actual impact on buildings energy use is not entirely captured by this estimate, as the heat generated in lighting is a major source of building cooling demand – up to 40 percent in a "typical" stock building.[4]

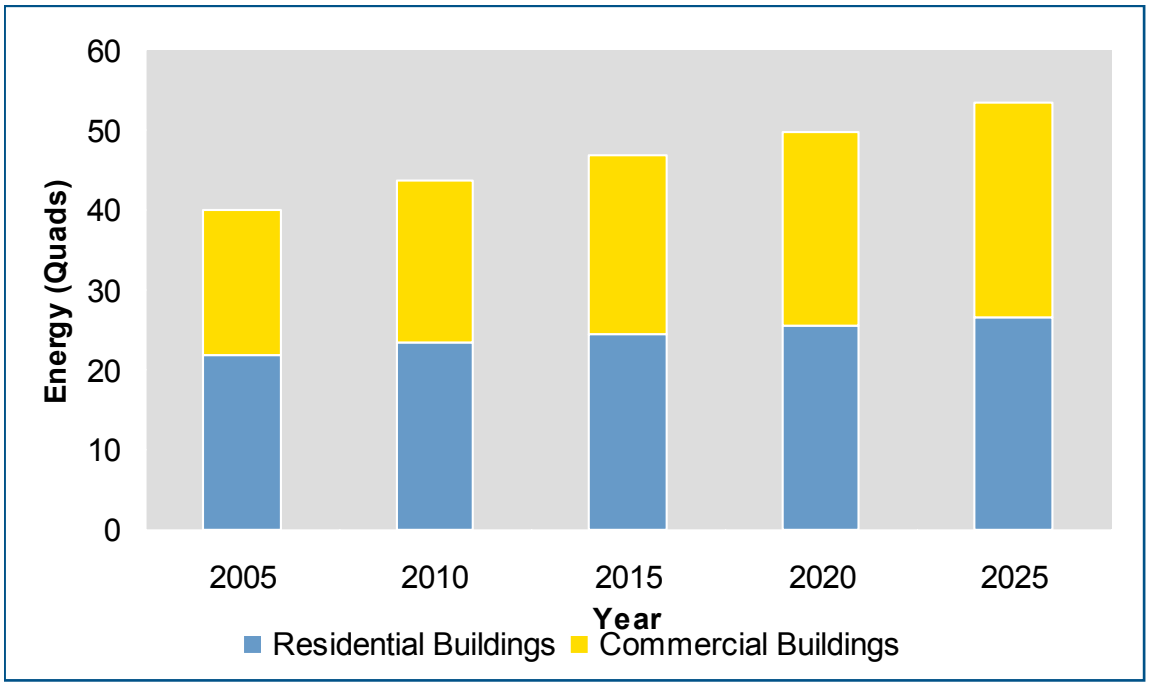
After lighting, the other important end-uses for commercial buildings are space conditioning (heating and then cooling) and then, with significantly lower energy demands, water heating, office equipment, and ventilation. While "other" appears as a significant end-use, it is critical to understand that this is an aggregation of heterogeneous energy demands, including automated teller machines, telecommunications equipment, medical equipment and so forth; it comprises many uses aggregated into one slice for expositional ease.

Actual energy use demand in commercial buildings is even more variable than in residential buildings. A large end-use in one commercial building could be a small-end use or non-existent in another commercial building. For example, cooking is a major end-use in restaurants, but irrelevant in warehouses, and water heating is a major end-use in hospitals and hotels, but not in offices or retail stores. Hospitals are 24/7 operations, while concert halls and theatres have very concentrated energy use periods. In single-

[3] BED
[4] BED

story buildings, cooling demand is partly determined by the roof; but in large multi-story buildings, cooling demand is determined by solar heat gain through windows and internal gains, and the roof is not relevant. Understanding this kind of variation is important in understanding the actual opportunities for advanced technology and systems concepts to reduce energy demand.

Figure 1-3 Projected Energy Use Growth[5]



Energy consumption has been increasing and is expected to continue to increase over the next two decades (Figure 1-3). The Energy Information Administration (EIA) expects the trend to continue for three principle reasons:

1. As the population grows and the economy expands, so do the number of homes, apartments, shopping malls, schools, hospitals, correctional institutes, and offices. In 1970, the U.S. population was a little over 200 million; on August 1, 2005, it was approximately 297 million.[6] By 2025, the Census Bureau projects it will be almost 340 million. Gross Domestic Product, which is today around $10 trillion will be nearly $19 trillion by 2025.[7] Consequently, EIA projects that the number of residential households will increase 1.1 percent per year and the total commercial square footage will increase by 1.7 percent per year through 2025.

2. The amount of floor space per person has also been increasing, both due to the construction of larger homes as well as decreases in the average number of

[5] *Annual Energy Outlook 2006*, Energy Information Administration. Hereafter, AEO.
[6] U.S. Census Bureau, *Table 1. Annual Estimates of the Population for the United States and States, and for Puerto Rico: April 1, 2000 to July 1, 2005*, Last revised December 22, 2005.
[7] AEO

occupants per household. The EIA's Annual Energy Outlook (AEO) projects that average house square footage will increase 0.5 percent per year through 2025.

3. The demand for the services energy provides has both changed in composition and increased in scale over time. For instance, air-conditioning, once a novelty in the 1950s and a luxury in the 1960s, is now commonplace. The same can be said for household appliances (e.g., washing machines and dryers), office equipment (e.g., fax machines and computers), and entertainment devices (e.g., 20-inch televisions, DVDs). EIA projects that "other" end uses will increase at the rate of 2.7 percent per year through 2025.

Based on these and other factors, future energy use in buildings will include the following trends, which serve to guide our decisions on Research and Development (R&D) priorities:

- Residential energy consumption is projected to grow at an average rate of 1.0 percent per year between 2005 and 2025, with the most rapid rate of growth projected by EIA for color televisions, personal computers, clothes washers and most significantly, for the undefined "other" uses which EIA projects will increase 2.7 percent per year. In terms of absolute energy use, however, the largest increases will be in space heating, lighting, and also, "other" uses.

- Commercial energy use is projected to grow at an average annual rate of 2.0 percent between 2005 and 2025, and will match residential energy demand by 2025. The most rapid growth rates in commercial energy use projected by EIA are for computers and office equipment. "Other" uses stands out for the magnitude of its absolute increase – 4.5 quads of projected growth over 2003 levels. (This "everything else" category includes telecommunications equipment, medical equipment, ATMs, pumps and backup generation systems).

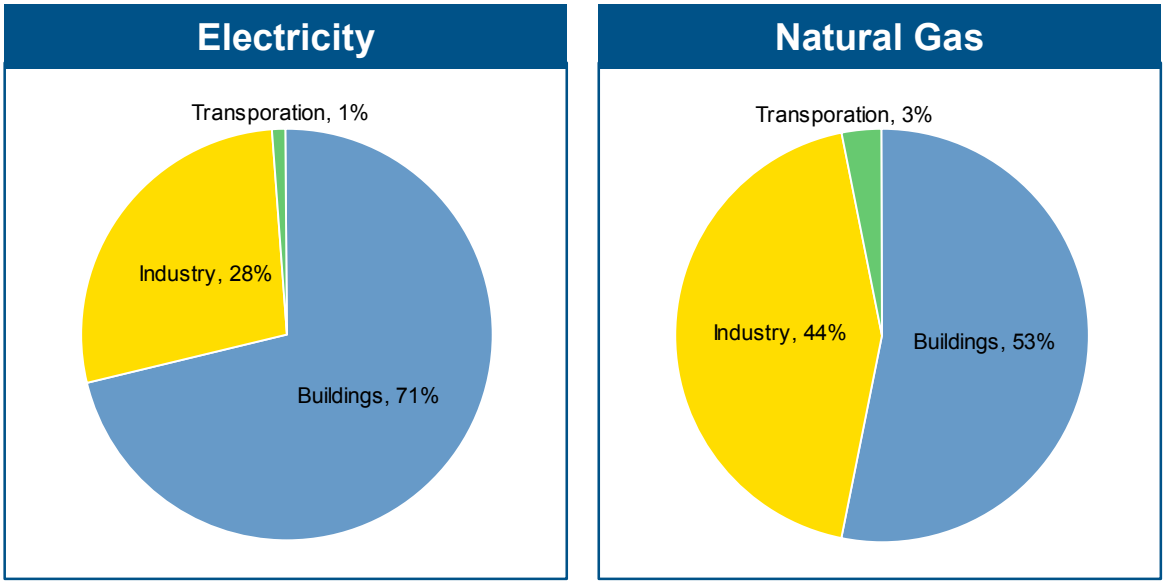
1.1.1 Reducing Electric Consumption

Several options exist for reducing the environmental and national security-related externalities associated with energy consumption in the U.S. Two important options include reducing our demand for energy in the three primary sectors: buildings, transportation and industry, and providing cleaner domestic energy generation technologies, such as renewably-generated power and renewably based liquid fuels. The "net zero energy" goal, of course, is a combination of these two options, an "insulate then insolate" approach which lowers loads and serves remaining loads with solar power.

Homes and commercial buildings are the dominant consumer of electricity in the U.S. at 71 percent (Figure 1-4). By 2025, per EIA, this figure will be 75 percent. From the standpoint of utility bills, buildings are even more significant, accounting for 80 percent of total expenditures on electricity.

Electric system summer peak demand, and the associated stress on transmission and distribution systems, is predominately building-related. It is largely caused by the demand for air conditioning in homes, offices, and other commercial buildings.

Figure 1-4 Electricity and Natural Gas Use, 2003[8]



1.1.2 Overview of Market Barriers

Building industry R&D investment is significantly less than 1 percent of revenues for a variety of reasons. The industry is extremely fragmented, with a large number of different types of firms required to build and operate a building (e.g., manufacturers, designers, builders, subcontractors, suppliers), limiting the ability of the private sector to effectively coordinate research. With the exception of some appliances and materials, firms are typically very small and represent a small portion of their overall market (for example, the top 5 homebuilders account for only 7 percent of the market) and are generally not large enough to undertake substantial research, or to realize more than a small portion of the resulting benefits themselves.

Building efficiency improvements entail unique market risks because they are relatively "invisible" and difficult to measure, making them difficult to market, especially without independent verification of savings levels. The relatively small size of building firms makes it very difficult for them to absorb the costs and risks of verifying the efficiency, safety, and health characteristics of new building designs and technologies. Even larger private sector organizations, such as the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI) have reduced R&D investments significantly in the face of increasing competition in these energy markets.

Another barrier is the compartmentalization of the building professions, in which architects and designers, developers, construction companies, engineering firms, and

[8] BED

energy services providers do not typically apply integrated strategies for siting, construction, operations, and maintenance.[9]

1.2 Internal Assessment and Program History and Progress

1.2.1 Program History and Inception Date

The debate throughout the 1970s around energy independence culminated in the creation of the Department of Energy and passage of the National Energy Act in 1978, which formed the basis for national energy policy in the late 1970s and early 1980s. The primary impact of the National Energy Act in this first period was to vigorously direct national policy at developing alternative sources of energy supply, including energy efficiency and renewable energy sources. The Energy Conservation and Production Act (ECPA) was passed in 1976 and called for mandatory energy efficiency performance standards for all new U.S. buildings. Funding for buildings research and activities was steadily increased from 1978 to 1980 after the creation of DOE. In particular, funding for appliance standards was increased over 40 percent in 1980. This was done in response to the amendments to the National Energy Conservation Policy Act (NECPA). These amendments changed the existing system, which relied on voluntary cooperation by manufacturers for reaching efficiency improvement targets, to a mandatory system that required individual appliances to meet or exceed minimum efficiency levels.[10]

During the 1980s, the Buildings R&D focus shifted away from its earlier emphasis on commercialization of technologies. Instead, attention was placed on long-term, high-risk research projects. Funding for the buildings system program was 20 percent lower in 1984 than it was in 1980. Comparing other programs in 1984 to their 1980 funding levels, the budget for the appliance standards program decreased by 72 percent over 1980 levels, funding for the technology and consumer products program fell 66 percent, and the budget for technology assessment and transfer decreased by over 95 percent.

The period from 1989 to 2001 saw a dramatic increase in the resources allocated to buildings. During this period, the research activity expanded from the narrower focus on long-term projects to also include research into the development and commercialization of buildings technologies. The Buildings Program increased its efforts to develop partnerships with private industry and to make energy efficient building technologies more accessible and commercially acceptable. In this sense, this latest period can be seen as a combination of the commercialization focus of the late 1970s and the long-term high-risk research from the 1980s.

Research goals during the 1990s also focused more on specific appliances and building components as a means for making buildings more energy efficient. New emphasis included appliance standards, building codes, and creation and expansion of the Energy

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[9] *Building Better Homes: Government Strategies for Promoting Innovation in Housing*, U.S. Department of Housing and Urban Development, Office of Policy Development and Research and the Partnership for Advancing Technology in Housing. Prepared by Rand Corp., 2003.

[10] U.S. Department of Energy, *Fiscal Year 1980 Congressional Budget Request: Energy Supply Research and Development, Volume Three.*

Star and Building America programs. While these were not specifically designed as research programs, they did receive R&D appropriations and activities within these programs became increasingly important throughout this period. In particular, electricity market deregulation resulted in a shift away from rebate-driven demand-side management programs and greater reliance on market transformation and labeling programs such as Energy Star, which helped shape the agendas in these programs.

When DOE was first formed, the Buildings Program was called the Office of Buildings and Community Systems (OBCS), which included R&D activities, regulatory programs (appliance and buildings standards), the Federal Energy Management Program (FEMP), and some community programs. In the 1980s, OBCS was changed to the Office of Buildings Technologies (OBT). FEMP was split off as a separate program in the early 1990s. In the mid-1990s, OBT and the state grant programs were combined into the Office of Building Technology, State, and Community Program (BTS). In 2002, BTS was split into essentially two programs, one of which is the current Building Technologies Program (BT). The current BT program includes building technology and systems research, appliance standards and building codes, and Energy Star.

In 2003, BT has developed a new long-term performance goal that accurately focuses on outcomes and meaningfully reflects the purpose of the program. By 2025, the Building Technologies Program will create technologies and design approaches that enable the construction of net-zero energy buildings at low incremental cost. A net zero energy building is a residential or commercial building with greatly reduced needs for energy through efficiency gains, with the balance of energy needs supplied by renewable technologies. While initially focused on new construction, these technologies and design approaches will have application to buildings constructed before 2025 resulting in substantial reduction in energy use for all building types and ages.

Driven by the National Energy Policy and DOE Strategic Plan, the move was to create a more strategic environment for selecting and conducting our research. BT realized, given our success in reducing energy intensity over the previous 25+ years, future energy savings were going to prove more difficult to achieve. The new goal builds on the success of our integration programs, while also providing direction for project selection in a flat or decreasing budget environment. It also is in response to the need for a more programmatic approach to DOE's activities.

1.2.2 Major Accomplishments

Historically, the DOE Buildings activities have resulted in technologies with proven energy savings and hence, proven cost savings. Buildings have produced significant results, and a few examples are shown below:

- U.S. Federal residential appliance standards, which became effective in the 1988-2001 period or will take effect by the end of 2007 (including refrigerators,

furnaces and central air conditioners), have an estimated cumulative net present value to consumers of approximately $80 billion by 2015.[11]

- In FY 2001, the National Research Council published Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000, in which seven building R&D case studies were reviewed. It concluded that DOE appears to have made a substantial contribution to significant changes in the U.S. lighting, glazing, and refrigeration markets, with benefits to consumer and the environment that exceed the entire Federal R&D investment in the buildings sector over the period under review.
- Three DOE buildings R&D innovations - low emissivity glass, electronic ballasts for fluorescent lamps, and advanced refrigerators - saved $30 billion in cumulative net cost savings.[12]

DOE has also played a driving role in shaping the building community's approach to energy use technology and techniques. Below is a brief summary comparing the state of the Building sector in 1978 to today:

Table 1-1 Changes in the Building Sector (1978 to Today)

1978 Base Conditions	Federally Driven Outcomes	Key Driver(s) for the change
Minimum efficiency standards for residential appliances and equipment do not exist.	Minimum Efficiency Standards for a large number of appliances are in effect and affecting sales of millions of units per year, including central air conditioners, heat pumps, furnaces, refrigerators and clothes washers. By law, DOE must upgrade standards to the maximum level of energy efficiency that is technically feasible and economically justified.	National legislation, including the National Appliance Energy Conservation Act, in part driven by the prospect of individual states promulgating different standards.
A refrigerator sold in this year would use about 1800 kWh/year.	A refrigerator sold today would use about 500 kWh/year.	Minimum efficiency standards, and DOE R&D breakthroughs as documented in the NRC report, "Was it worth it?"
"Energy efficiency" is a term without a technical/ empirical definition when applied to equipment and appliances. (You cannot manage what you cannot measure)	Standard national DOE test procedures are in place for a large number of appliances and equipment. The test procedures measure energy efficiency & energy use, and created the language with which we discuss energy efficiency in buildings (AFUE, SEER, etc did not exist previously)	NAECA, EPAct and other enabling legislation,
Objective, national rating	Voluntary national rating standards for	Energy Policy Act of

[11] *Realized and Prospective Impacts of U.S. Energy Efficiency Standards for Residential Appliances,* U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program. Prepared by Lawrence Berkeley National Laboratory, June 2002.

[12] *Energy Research at DOE: Was it Worth It? Energy Efficiency and Fossil Energy Research 1978 – 2000,* 2001, National Academies Press.

1978 Base Conditions	Federally Driven Outcomes	Key Driver(s) for the change
procedures for evaluating the thermal and solar heat gain performance of windows do not exist.	windows exist, allowing consumers to compare energy performance levels.	1992
Minimum energy efficiency standards for commercial furnaces and boilers and air conditioners, water heaters and distribution transformers do not exist.	Minimum national standards are in effect for commercial equipment.	Energy Policy Act of 1992.
Chlorofluorocarbons are the standard working fluid in air conditioners and refrigeration equipment.	Non-CFC working fluids have replaced CFC-12 in all of these applications; the American Refrigeration Institute acknowledges DOE's research role in researching alternatives. Additionally, the R&D allowed DOE to pursue standards activities for products such as central A/C, refrigerators and water heaters.	Montreal Protocol Treaty on Ozone Depleting Substances.
Objective consumer information on superior energy appliances technologies does not exist in the marketplace. (Reliable information is a scarce good.)	DOE/EPA Energy Star label, identifying superior performance, appears on a very wide range of products, including appliances, cooling and heating equipment, and home electronics.	Energy Policy Act of 1992.
New construction just a combination of products, not using a systems "whole building" approach	New construction firms moving to systems approach to buildings, allowing for Energy Star Homes to reach over 10% of new construction	Builders seeking affordable, more efficient homes
Inefficient incandescent and magnetic ballast fluorescent lighting	Electronic ballast standards, along with market introduction of CFLs and more efficient lighting designs.	Energy Policy Act of 1992
Fundamental information about the energy use patterns and characteristics of U.S. homes and buildings does not exist, such as the standard pie chart showing energy by end-uses. National EIA survey results (CBECS and RECS) have not yet been published.	25+ years of DOE and EIA survey work and analysis have greatly expanded our understanding of the energy flows and opportunities in this sector.	Creation and funding of EIA; need for analysis-based decision making in BT.

1.3 Program Justification & Federal Role

1.3.1 National Need

President Bush's National Energy Policy (NEP) calls for "reliable, affordable, and environmentally sound energy for America's future." In order to achieve this vision, the President's plan has defined several objectives including increasing energy conservation, relieving congestion on the Nation's electricity transmission and distribution systems,

and establishing a national priority for improving energy efficiency and protecting our environment.[13]

Increasing the energy efficiency of residential and commercial buildings leads to reductions in the consumption of oil, natural gas, and electricity, thus reducing America's vulnerability to energy supply disruptions, energy price spikes, and constraints in the Nation's electricity infrastructure. This program helps to address the NEP recommendation to reduce energy intensity and make energy efficiency a national priority (Chapter 4), modernize conservation (Chapter 4) and improve affordability (Chapter 2). Buildings also account for about a third of U.S. carbon emissions. This program helps address the President's goal to cut greenhouse gas intensity by 18 percent over the next 10 years.

The implementation of the President's national energy plan is a top priority for the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). Because the NEP specifically calls for improvements in the energy efficiency of residential and commercial buildings and of energy-using equipment in these buildings, the EERE's Building Technologies Program plays a critical role in achieving this mission.

Increasing the energy efficiency of residential and commercial buildings leads to increased energy conservation by reducing the consumption of electricity, natural gas, and to a far lesser extent, oil. The reduction in energy consumption decreases America's vulnerability to potential energy supply disruptions (including of imported natural gas) and price spikes in heating oil, natural gas, and electricity. With our Nation's annual energy bill for residential and commercial buildings reaching $305 billion in 2003, the economic advantages of reducing energy expenditures can be significant.[14]

Since buildings' power demand is the majority of peak electricity use, reducing the electricity used by buildings can also relieve congestion on the Nation's electricity distribution systems. By alleviating the congestion, buildings can improve the security of the Nation's energy production by lessening the need for larger distribution systems and consequently, supporting the Secretary's mission to "protect delivery infrastructure against credible terrorist threats."[15]

In addition, improving the energy efficiency of buildings reduces the burdens on the environment by reducing the need to combust fossil fuels, either on-site (for space and water heating) or at power plants to generate electricity. In turn, this reduces the airborne emissions associated with fossil fuel combustion, including emissions of carbon dioxide, the principal greenhouse gas associated with global climate change. In 2003, U.S. buildings accounted for 39 percent of the nation's anthropogenic carbon emissions, and 9 percent of global anthropogenic emissions.

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[13] National Energy Policy Development Group, *National Energy Policy,* May 2001.
[14] BED
[15] U.S. Department of Energy, *Fiscal Year 2004 - 2008 Planning Guidance*. (Unavailable)

1.3.2 Federal Government Ownership

The Building Technologies Program funds research, development, and demonstration activities linked to public-private partnerships. The government's current role is to concentrate funding on high-risk, pre-competitive research in the early phases of development. As activities progress through the stages of developing technology to validating technical targets, the government's cost share will diminish. The government's role will bring technologies to the point where the private sector can successfully integrate them into buildings and then decide how best to commercialize technologies.

BT has assumed this Federal role because market pressures make it difficult for the building industry to earn an acceptable return on research investments. Building efficiency improvements entail unique market risks because they are relatively "invisible" and often difficult to measure, making them difficult to market, especially without independent verification of savings levels. In addition, consumers are often unwilling to pay higher initial costs to achieve lower life cycle costs, a tradeoff inherent in some energy efficiency technologies, unless there is a positive cash flow between the mortgage and the utility bills.

The relatively small size of most construction industry firms also makes it very difficult for them to absorb the costs and risks of verifying and marketing the efficiency, safety, and health characteristics of new building designs and technologies. While many large corporations in the components and materials part of the building industry spend between 2 and 4 percent of revenue (national average in other industries is closer to 3.5 percent) on R&D, the construction part of the building industry spends relatively little on R&D. Revenue spent on energy R&D is even less, on average constituting only 0.6 percent of all industry revenue in 2000.[16] While this is, in part, due to the cyclical nature of the market, the industry is also dominated by a large number of small firms (relatively speaking) that can ill afford research programs, which prevents coordinated or integrated research.

Furthermore, vast variability exists within buildings themselves, so that even a single community might contain hundreds of styles and sizes. One result of all this diversity is that component integration into buildings is less than optimal. Hence, buildings are typically designed and constructed as complex amalgamations of individual technologies, each of which carries out its intended function largely independent of (or even in spite of) others, rather than as a tightly integrated system of interrelated components. Inefficiencies and lost energy opportunities, not to mention potential reductions in construction costs, are frequent consequences of this situation. Given this lack of "whole buildings" research in the private sector, DOE is ideally suited to bring together the component research being conducted in the private sector with best practices in the construction industry to build and expand energy efficient buildings with minimal impact on the cost to the consumer.

[16] BED

In addition to compensating for little private sector investment in building R&D, the federal government also has a regulatory role in protecting consumers from products that consume uneconomical amounts of energy or bring about undue environmental degradation as a result of their use. BT accordingly establishes efficiency standards for energy consuming equipment used in residential and commercial buildings under the authority of the Energy Policy and Conservation Act of 1975, as amended. BT also assists in devising and promulgating building codes that fall under state and local jurisdiction.

1.3.3 Uniqueness and Criticality

The BT mission of improving the energy efficient performance of building equipment, subsystems and whole buildings through research, development, demonstration and deployment; support and promotion of energy building codes; and the promulgation and enforcement of National lighting and appliance standards is unique in the Federal government. While the program integrates the results of supply-oriented programs, such as the Distributed Energy Resources Program and the Solar Technologies Program, it does not fund research and development topics addressed by those programs. The majority of the program's activities are in the area of applied technology research and development, which includes efforts that are in our national interest and have potentially significant public benefit, but are too risky or long-term to be conducted by the private sector alone. These technology development efforts are supplemented with activities to address the needs for economically justified energy building codes and National appliance standards, and to accomplish effective technology transfer and information exchange. In terms of effectiveness National appliance standards, which mandate the efficiency level of energy using equipment, are the most effective at obtaining energy savings due to 100 percent market penetration. Energy building codes are effective when adopted and enforced by states and local jurisdictions, but have not been uniformly adopted or enforced. Technologies, design tools, methods, and practices produced are subject to competitive market forces, and thus do not achieve complete market penetration.

1.3.4 Other Federal Programs Complemented

Many Buildings subprograms (windows, lighting, commercial buildings, building envelope, space conditioning) work closely with industry to identify pre-competitive R&D needs and prepare roadmaps. The program coordinates with the U.S. Department of Housing and Urban Development (HUD) and others in certain multi-agency efforts, such as the Partnership for Advanced Technology in Housing (PATH). Through the efforts of the Association of States Research and Technology Transfer Institute (ASERTTI), coordinated research agendas are developed with the counterpart State research entities. BT integrates its unique regulatory authorities within the research programs to allow full consideration of federal actions.

1.4 Program Vision

BT has defined its central vision as the realization of marketable net-zero energy buildings through the development of conservation technologies and practices. It is recognized that ZEB will require renewable energy technologies that are being developed

by other EERE programs and industry. BT will focus on reducing the energy demand in buildings in a manner that will also allow for the successful integration of renewable energy technologies (both on-site and purchased) acceptable to the market. The strategic goal is for the acceptance of low-energy and net-zero energy buildings in the marketplace.

1.5 Program Mission

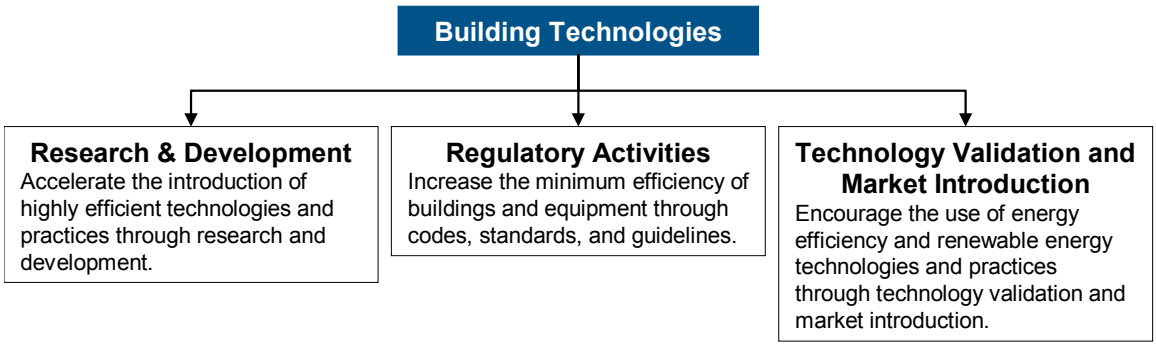
The mission of the Building Technologies Program is to develop technologies, techniques and tools for making residential and commercial buildings more energy efficient, productive, and affordable. This involves research, development, demonstration, and technology transfer activities in partnership with industry, government agencies, universities, and national laboratories. The portfolio of activities includes efforts to improve the energy efficiency of building components and equipment and their effective integration using whole building system design techniques. It also involves the development of building codes and equipment standards, as well as the integration of renewable energy systems into building design and operation.

1.6 Program Approach

BT has identified a three strategy approach to overcome barriers and achieve the goal of ZEB by 2025. The three strategies have evolved from careful consideration of the goal and a thorough situation analysis. BT subprograms will be designed to capitalize on the interactive, synergistic benefits of our three implementation strategies.

The three strategies build upon each other, and their crosscutting nature should make the program stronger than it would be if the strategies were pursued isolation. A prioritized and integrated portfolio of research and development will establish the technology base for future energy savings.

Figure 1-5 Building Technologies Program Strategies



In addition to the Research and Development of efficient technologies, the Regulatory Activities will eliminate the most inefficient existing technologies in the market. Technology Validation and Market Introduction will speed the introduction of new technologies and the widespread use of highly efficient technologies already on the market and provide valuable feedback for future R&D.

The three strategies combined form the complete approach to reducing energy consumption in buildings. BT's challenge is to bring the appropriate strategies to bear in order to exploit the opportunities, while designing programs that give appropriate consideration to the marketplace and barriers to energy efficiency.

1.7 Program Performance Goals

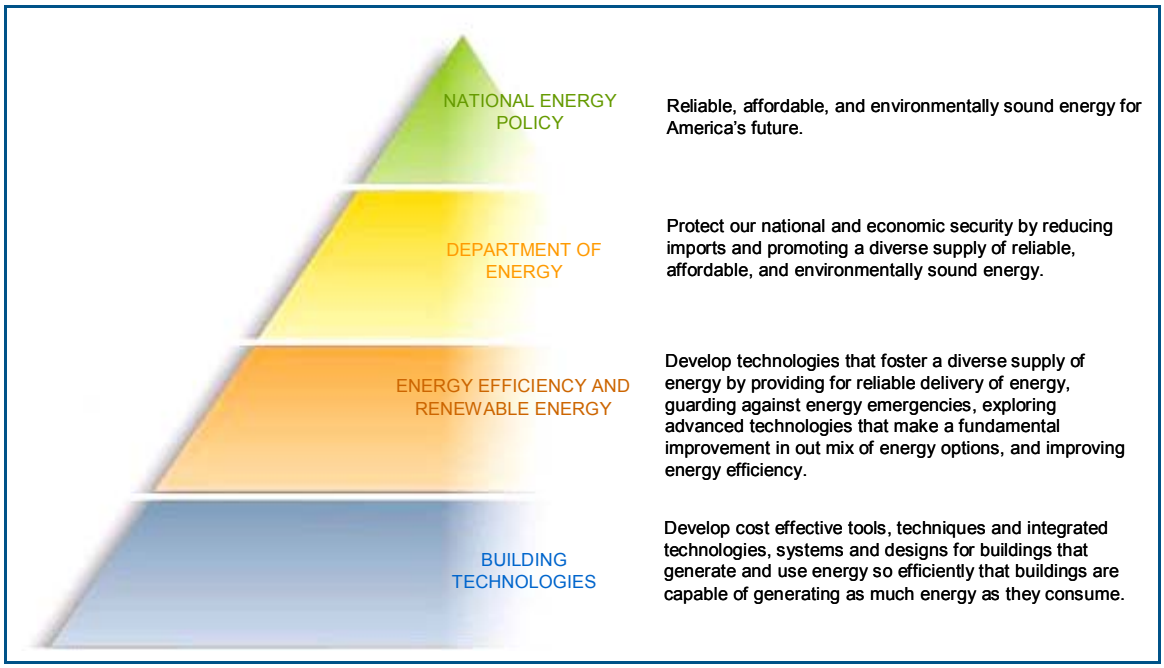
Each of the three BT strategies has a performance goal that contributes to achievement of the BT strategic goal including:

- Research and Development: Accelerate the introduction of highly efficient technologies and practices through R&D to achieve net-zero energy homes by 2020 and net-zero energy buildings by 2025.
- Regulatory Activities: By 2010, issue 13 formal proposals, consistent with enacted law, for enhanced product standards and test procedures to increase the minimum efficiency levels of buildings.
- Technology Validation and Market Introduction: Remove technical, financial, and availability hurdles to new, emerging energy efficient technologies to achieve net-zero energy homes by 2020 and net-zero energy buildings by 2025.

1.8 Program Strategic Goal

The Department's Strategic Plan identifies four strategic goals (one each for defense, energy, science, and environmental aspects of the mission) plus seven general goals that tie to the strategic goals. The Building Technologies Program supports the following DOE strategic and program goals, shown below in Building Technologies Goal Cascade.

Figure 1-6 Building Technologies Goal Cascade



In support of the President's policies and initiatives, BT has embraced the strategic goal of developing Net-Zero Energy Buildings (ZEB) to reduce national energy demand. The program has defined its strategic goal more specifically as:

To create technologies and design approaches that enable net-zero energy buildings at low incremental cost by 2025. A net-zero energy building is a residential or commercial building with greatly reduced needs for energy through efficiency gains (60% to 70% less than conventional practice), with the balance of energy needs supplied by renewable technologies. These efficiency gains will have application to buildings constructed before 2025 resulting in a substantial reduction in energy use throughout the sector.

1.9 Program Outputs

The key outputs from the Building Technologies Program are the technologies and systems that allow the building community, contractors and building owners to reduce their energy consumption and costs. Below are some key outputs for the next five years:

- Research and Development:
    - For residential buildings, five clear technology packages that can reduce energy consumption in new buildings by at least 40 percent.
    - In commercial buildings, key technology pathways to achieve 30 to 50 percent reduction in the purchased energy use in new, small commercial buildings relative to ASHRAE 90.1-2004
    - Continued development of white-light solid state lighting, reaching a commercial efficacy of 100 lumens per watt by 2011.
    - An improved EnergyPlus, which can evaluate 90 percent of the state-of-the art technologies under development by BT R&D
- Regulatory Activities:
    - Test procedures for torchieres, ceiling fans, commercial reach-in refrigerators, vending machines and beverage merchandisers, and incandescent reflector lamps
    - Final rules for distribution transformers, commercial unitary AC/HP, furnaces and boilers, and ASHRAE products
    - Upgraded 2009 International Energy Conservation Code to include improved lighting, envelope and mechanical requirements
- Technology Validation and Market Introduction:
    - New criteria for clothes washers and dishwashers, and the expansion of the program to include water heaters, solid state lighting and other emerging product.

1.10 Program Outcomes

The Building Technologies Program supports DOE's goal to improve energy security by developing reliable, affordable and environmentally sound technologies that significantly reduce the energy consumption and peak electrical demands of residential and commercial buildings. More detailed, integrated and comprehensive economic, energy and energy security benefits estimates are provided in the Program Benefits section in Chapter 2.